SURFACE CHANGES ON IO DURING THE GALILEO MISSION. P. E. Geissler[1] A. S. McEwen[1], C. Phillips[2], L. Keszthelyi[1], and J. Spencer[3], [1]Lunar and Planetary Laboratory, University of Arizona (geissler@lpl.arizona.edu), [2]SETI Institute, Mountain View, CA, [3]Lowell Observatory, Flagstaff AZ.

Introduction: Several questions surround the mechanisms of resurfacing, the erasure of surface deposits, the flux of materials escaping into space, and the radiation of thermal energy from Io that can only be addressed with a detailed knowledge of Io's eruption history. Galileo dust and plasma monitoring instruments detected significant variability in the concentrations of dust and charged particles from one spacecraft orbit to the next that are believed to be linked to volcanic episodes on the satellite (e.g., [1-3]), but no direct relationships have so far been established. Ground-based, NIMS and SSI observations monitored variations in thermal emission from more than 100 hot spots on Io during the Galileo era [4] but clear links between thermal emission and eruptive style have not yet been established. It remains to be determined whether Io's thermal radiation is dominated by the eruption of new lava flows or the quiet overturning of lava lakes, a question that has significant impact on Io's resurfacing rate. It is not yet known how much of Io's prodigious resurfacing is caused by lava flows and how much is due to plume deposits, or whether the deposition of pyroclastics by plumes is dominated by the few largest plumes or the more numerous smaller plumes. Only ~30 large-scale surface changes took place between the Voyager encounters and the start of the Galileo mission [5], leaving as much as 90% of the surface apparently unaltered [6], but it is unclear whether these areas had remained inactive over the entire period or whether eruptions might have taken place but their deposits had already faded by the time of Galileo's arrival.

To begin to answer some of these questions, we have undertaken to document Io's volcanic activity during the Galileo era on the basis of surface changes seen in distant global monitoring images that were taken repeatedly throughout the 5 year mission. We have determined as closely as possible the dates of the changes (to within the limits imposed by the imaging coverage) and attempted to distinguish between volcanic eruptions and other types of surface changes. For each volcanic plume deposit, we have made measurements of the areal extent, maximum range, and radius of any ring present. We have performed statistical analyses of these measurements, correlated surface changes with plume sightings, detections of high-temperature hot spots, and Galileo Dust Detector measurements, and examined the relevance of the findings to the questions raised above.

Approach: Identification and mapping of surface changes from Galileo images is complicated by uneven temporal coverage, marked color variations that alter Io's appearance when seen through different colored filters, and photometric variations that produce dramatic contrast reversals depending upon the phase angle of the observations. Our approach was to make 3 passes through the imaging data. The first pass examined well matched color and monochrome images to identify sites of definite change and determine periods in which these areas were inactive. The second pass examined all the available images of each active volcanic center in chronological order to determine the history of its eruptions. The final step involved scrutinizing pairs of images taken before and after each identified surface change to ascertain the details of each eruption.

Animated sequences of consecutive Galileo images illustrating most of Io's surface changes are available at
http://pirlwww.lpl.arizona.edu/~geissler/Volcanic_centers/GIF

Results: We have found more than 80 apparent surface changes that took place on Io during the 5 year period of observation, ranging from giant plume deposits to subtle changes in the color or albedo of patera surfaces. Explosive volcanic activity was discovered at four previously unrecognized centers: an un-named patera to the south of Karei that produced a Pele-sized red ring, a patera to the west of Zal that produced a small circular bright deposit, a large orange ring detected near the north pole of Io, and a small bright ring near Io's south pole. Only a handful of Io's many active volcanoes produced large scale explosive eruptions, and several of these erupted repeatedly, leaving at least 83% of Io's surface unaltered throughout the Galileo mission. Most of the hot spots detected from SSI, NIMS and groundbased thermal observations caused no noticeable surface changes greater than 10 km in extent over the five year period. Surface changes were found at every location where active plumes were identified, including Acala which was never seen in sunlight and was only detected through auroral emissions during eclipse. Two types of plumes are distinguished on the basis of the size and color of their de-

posits, confirming post-Voyager suggestions by McEwen and Soderblom (1983). Smaller plumes produce near-circular rings typically 150 to 200 km in radius that are white or yellow in color unless contaminated with silicates, and frequently coat their surroundings with frosts of fine-grained SO2. The larger plumes are much less numerous, limited to a half dozen examples, and produce oval, orange or red, sulfur-rich rings with maximum radii in the north-south direction that are typically in the range from 500 to 550 km. Both types of plumes can be either episodic or quasi-continuous over a five year period. Repeated eruptions of the smaller SO2-rich plumes likely contribute significantly to Io's resurfacing rate, whereas dust ejection is likely dominated by the tenuous giant plumes. Both types of plume deposits fade on time-scales of months to years through burial and alteration. Episodic seepages of SO2 at Haemus Montes, Zal Montes, Dorian Montes, and the plateau to the north of Pillan Patera may have been triggered by activity at nearby volcanic centers.

References: [1] Krueger, H. et al., 2003. In Bagenal, F., McKinnon, W., Dowling, T., eds. *Jupiter: Planet, Satellites and Magnetosphere*. Boulder: Colorado Univ. Press. In press. [2] Russell, C. T. and M. G. Kivelson 2001. *JGR* 106, 33267-33272. [3] Frank, L. A. and W. R. Paterson 2001. *JGR* 106, 6131-6150. [4] Lopes, R. M. C. et al., 2001. *JGR* 106, 33053-33078. [5] McEwen, A. S. et al., 1998. *Icarus* 135, 181-219. [6] Geissler, P. E. et al., 1999. *Icarus* 140, 265-282.

Figure Captions: 1. (Top Left) Sizes of explosive volcanic deposits. 2. (Top Right) Dates of major explosive eruptions (heavy lines), minor changes (dashed lines) and inactivity (light lines). Also shown are sightings of plumes in daylight (P), eclipse (E), and both (B) along with SSI detections of thermal emission (dots). 3. (Bottom) Distribution of volcanic plume deposits.